Study Plan for
Washington Aqueduct
Water Quality Studies

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Introduction

The U.S. Army Corps of Engineers owns and operates the Dalecarlia and McMillan water treatment plants which supply water to the District of Columbia, Arlington, and Falls Church. Raw water is obtained for both plants from the Great Falls Raw Water Intake or the Little Falls Pumping Station on the Potomac River. The water flows through the Dalecarlia Reservoir and is then diverted for settling to either the Dalecarlia plant or the Georgetown Reservoirs.

Residual solids from the Dalecarlia plant sedimentation basins are periodically discharged to the Potomac River through Outfall 002. Residuals from the McMillan plant are generated in the Georgetown Reservoir Basins 1 and 2. Those residuals are periodically discharged into the Potomac River via Outfalls 003 and 004. These discharges are allowed in the Aqueduct's NPDES permit.

The timing of these residual discharges is dictated by a number of factors. If permit conditions are satisfied (e.g., acceptably high river level and/or ambient turbidity condition), then a sedimentation basin is usually discharged based on a general frequency (e.g., 3 or 4 times a year at Dalecarlia and twice a year at Georgetown), or the observation of excess solids buildup.

This water quality study plan was developed to be responsive to the specific technical issues raised by U.S. EPA staff in discussion documents and conference calls on 3 October and 13 November 97, written comments dated March 1998, and follow-up negotiations from January-March 1999. The proposed studies are also influenced by the November 97 site visit to observe the cleaning of the Georgetown Reservoir basin and the discharges from Outfalls 003. Section 1 of this study plan addresses effluent dilution and fate issues, which are critical to interpreting all of the subsequent information using U.S. EPA=s (1991) water quality-based approach. Section 2 discusses the laboratory testing to quantify the toxicity of whole effluent, effluent supernatant, and solid phases of the effluent, and Section 3 addresses chemical testing. Fishery studies are described in Section 4 and an approach for determining a site-specific aluminum criterion is presented in Section 5. An artificial substrate approach for evaluating potential effects to the benthic invertebrate community is presented in Section 6.

1. Potomac River Modeling for Effluent Dilution and Fate

1.1 Modeling Goals

The proposed numerical model of the Potomac River will simulate both river flow and the suspended solids plume from the Washington Aqueduct discharges. The primary objective of the modeling is to determine acute and chronic dilution factors as a function of effluent loading and river flow. The determination of both water column dilution factors and the spatial distribution of particle deposition will allow potential areas of concern to be identified. The proposed model domain will extend from slightly upstream of Outfall 002 to the downstream end of Roosevelt Island.

1.2 Model Selection

A detailed and finely calibrated hydrodynamic model is difficult to develop for hydrologically complex sites such as the Potomac River. Sedimentation may occur at many locations including back eddies and other irregular channel features, some of which exceed a model=s capability to represent. However, the capabilities of a hydrodynamic model to serve as a tool to examine mixing zone issues can be maximized by proper model selection and the collection of appropriate field data.

The model will be selected based upon key site characteristics. The relatively shallow nature of the Potomac River in relation to its width makes a 2-dimensional (vertically mixed) hydrodynamic model appropriate. In addition to hydrodynamic flow routines, the model should have the capability to simulate suspended solids and sedimentation processes. A temporally dynamic model (rather than steady state) will allow the simulation of the several hour discharge period for solids and the resultant plume build-up and dissipation. Sedimentation rates vary both laterally and longitudinally in response to river velocity caused by changes in cross-section and by reduced velocity areas beyond the main channel. The sedimentation routine should have the capability to respond to cell-by-cell variability in river velocity rather than employing global values. A finite-element model has the capability to use a varying model cell size which would allow a finer model grid to be used in the near-field area of concern (i.e., the acute mixing zone).

Two models with potential applicability are U.S. EPA=s WASP5 model and the TABS-2 model which is supported by the U.S. Army Corps of Engineers.

> WASP5 has more limited suspended solids routines, and the occurrence of sedimentation is not directly linked within the WASP5 model to the cell-by-cell velocity field. As a result the model does not internally vary the sedimentation rate between low and high velocity regions, but this rate is left as a parameter for the user to control in the input file.
>
> The TABS-2 modeling system includes a 2-dimensional hydrodynamic model, and sedimentation is carried out in the companion model STUDH. The TABS-2 model employs shear stresses at the bed-water column interface to determine deposition or erosion spatially over the 2-dimensional velocity field.

Both models can use a variable cell size to provide higher spatial resolution in areas of potential concern and can perform time varying simulations. The more detailed hydrological and suspended solids processes in a model such as TABS-2 makes it a better choice for this water quality program than the more widely known WASP5 model. The D.C. Department of Health has developed a WASP/TAM [Tidal Anacostia Model] model which is based on U.S. EPA's WASP5 model. It is anticipated that the model used for the Aqueduct project will perform more detailed hydrodynamic calculations within the study area than the TAM model developed for Total Maximum Daily Load calculations for the Anacostia River watershed. However, the District's WASP/TAM model will be examined and appropriate attributes including boundary conditions and model grid will be incorporated or used as a basis for additional model refinement.

A mixing zone model such as U.S. EPA=s CORMIX has limited applicability to represent the Washington Aqueduct discharges. At many sites, a model such as CORMIX is suitable for performing mixing zone analyses -- particularly in the near-field region associated with the *acute* mixing zone. However, at spatial scales expected to be associated with a *chronic* mixing zone for the Potomac River, a hydrodynamic model (as discussed in the previous paragraph) is more appropriate. The CORMIX model may be suitable for acute mixing analysis at Outfall 002 where the discharge is located adjacent to a deeper cross-section. However, at Outfall 003 and 004 the existing shallow shoreline discharge may be incompatible with the CORMIX model and acute mixing will most likely need to be determined using a hydrodynamic model.

1.3 Data Requirements and Model Calibration

The field work required to provide data for model parameterization and calibration will include the following tasks:

- Bathymetric Survey
- TSS plume mapping during one discharge event at both Outfalls 002 and 003
- Particle size distribution and settling velocity data for effluent samples
- Dye study to determine near- and far-field dispersion coefficients

The primary data requirements to develop the hydrodynamic model are (1) channel geometry data and (2) plume mapping data under known effluent and river flow conditions for establishing longitudinal and lateral dispersion.

A bathymetric survey will be performed by measuring depths along transects within the proposed model domain (which extends from above Outfall 002 to the downstream end of Roosevelt Island). The measured transects will include the proposed transects for the TSS plume mapping surveys and additional transects, as necessary, including the channels on both sides of Roosevelt Island, to provide adequate channel geometry data for the hydrodynamic model. Instream velocities will be measured along one transect representative of the deep channel and the wide shallow shoreline areas downstream of Outfall 003. The cross sectional velocity data will be used for model verification of the partitioning of the total flow along the transect. A water level recorder will be installed within the study area during each field survey. The water level data will allow the tidally influenced elevations measured during the bathymetric survey to be related to a common datum, and provide assistance in establishing the water-level boundary condition used at the downstream end of the model.

Sampling transects for the TSS plume-mapping survey will be selected at locations downstream of Outfalls 002 and 003. Near field sampling at Outfall 002 is unsafe and will not be attempted. The discharge event will be monitored at transects further downstream as the river broadens and slows down. The number of transects will be dependent on the length of the discharge event. The transect grid at Outfall 003 will extend downstream beyond Outfall 004. River characteristics are similar at Outfalls 003 and 004 and the Outfall 003 plume survey will provide model calibration for both reaches. A transect will also be sampled upstream of the surveyed outfall to provide ambient (background) TSS data. The TSS plume-mapping surveys will consist of both continuous transects performed from a boat, and grab samples. On the boat a turbidity sensor will be mounted at a fixed 1-ft depth. Turbidity readings will be continuously recorded at a 2-second sampling interval as the boat moves along the transect grid. The boat will be equipped with a global positioning system (GPS) and the location information will also be continuously recorded. During the Outfall 003 survey, a second field crew will collect grab samples in the shore zone which can not be reached by the boat. At select locations, grab samples will also be obtained along the boat transects. The grab samples will be analyzed for TSS, turbidity, and aluminum.

During a discharge event and associated TSS plume mapping, effluent flow will be estimated by a composite of several methods. Effluent velocity measurements will be made at an available access point such as the open sluice before entering the closed pipeline or at a manhole. The Aqueduct will also provide an estimate of the flow used during the basin cleaning (e.g., metering the fire hoses used to push out the solids). These TSS and flow data will allow an estimate of the relative contribution of solids to be calculated (Aqueduct versus river).

The water released during a discharge event can be mapped using Rhodamine WT dye tracing techniques. A dye study performed independently of a solids discharge event will provide additional field data to calibrate the lateral dispersion coefficients in the model. If properly scheduled, the opportunity exists to perform a dye study on the day prior to the residual solids discharge event as the reservoir is being drawn down. During the period of reservoir draw down, a representative flow is present at the outfalls which, except for an initial flush, does not contain a high TSS loading. A dye study performed during the period of reservoir drawdown should allow a longer sampling period for the collection of data along the river transects than the residual solids discharge event. The dye study should also provide for a more uniform discharge loading and higher precision in the plume measurements which will allow for better dilution contours from the field data. The availability of both TSS and dye mapping data at each outfall, most likely under different discharge flow conditions, will provide useful plume mixing and dispersion information to the model during the calibration process.

During the dye mapping survey, Rhodamine WT dye will be continuously injected at a manhole or wet well between the reservoir and the river outfall. The mapping survey will be performed along the same transect grid as established for the TSS plume mapping. Similarly to the TSS plume mapping, dye data will be continuously collected along transects with a fluorometer intake set at a fixed near-surface depth on the survey boat. Grab samples for dye measurements will also be collected in the near-shore zone at Outfall 003 where the boat cannot reach. Effluent samples for the analysis of TSS will be collected during the drawdown period to characterize the solids loading.

A 2-dimensional cell grid will be developed for the hydrodynamic model based upon the channel geometry data from the bathymetric survey. The use of a finite-element model will allow the selection of a finer grid in the near-field region of concern for the acute dilution factor. With a defined cross-sectional area, channel slope, and appropriate channel friction coefficients, a hydrodynamic model will predict water elevation for a given flow. Since the study area is tidally influenced, a downstream elevation boundary condition will be required in the model to properly represent the time varying river cross-section and corresponding velocities. Longitudinal and lateral dispersion in the model will be adjusted based upon the turbidity and dye data collected along lateral transects during the plume mapping surveys. Particle size distribution and settling velocity data for several effluent samples will be used to parameterize the sedimentation procedures. These additional data will supplement the particle size data available in the Dynamac (1992) report.

1.4 Model Scenarios

The calibrated model will be used to determine acute and chronic dilution factors at each of the three outfalls. Water quality regulations for the District of Columbia state that a chronic mixing zone shall not exceed 10 percent of the cross-sectional area and shall not occupy more than one-third of the width of the waterway. The dilution present at the downstream location where the plume width meets the spatial dimension of the allowed mixing zone will be determined from the model output. Allowed dimensions for an acute mixing zone are not addressed in the District of Columbia=s water quality regulations. Guidance for determining an acute mixing zone will therefore be based upon the U.S. EPA=s (1991) Technical Support Document for Water Quality-Based Toxics Control. Application of the TSD guidance for determining an acute mixing zone is difficult at existing outfall locations because several of the outfalls structures are set back from the shoreline (Outfalls 003 and 004). However, one method in the TSD for determining an acute mixing zone is based upon a 1-hour float time. With this method, an acute dilution factor is calculated from the one-hour time-weighted average exposure concentration which would be experienced by a drifting organism. One-hour average exposure concentrations can be determined by performing particle tracking within the hydrodynamic model.

Acute and chronic dilution factors will be determined for a range of river flows and discharge mass loadings. Model scenarios will include river flows both above and below the existing 3.5 bgd release condition. The dilution factors will allow instream concentrations at the edge of the mixing zones to be compared to appropriate water quality standards for determining under what discharge and river flow conditions, if any, the discharge may not be in compliance. The model will allow scenarios such as increasing the duration of the discharge period to be examined (e.g., 8-10 hr. discharge period rather than a 3-4 hr period). A model scenario simulating releases while the reservoir is being drawn down prior to the discharge of the residual solids will be included. Alternative discharge locations (such as an offshore diffuser) can also be examined.

The model=s capability to predict the suspension/sedimentation of discharged material as a function of particle size and river flow will address environmental concerns which may extend beyond the mixing zones. The transport and settling of the solids loading during a discharge event will be characterized to the downstream end of Roosevelt Island. The availability of the predicted plume distribution (dilution) in the water column, and the associated spatial distribution of sedimentation will provide for the identification of potential impact areas.

2. Effluent Toxicity Testing

2.1 Toxicity Testing Goals

The toxicity of the discharges to freshwater test species will be quantified to determine whether the effluents have a reasonable potential to be toxic at the edge of mixing zones. Acute toxicity testing will be conducted on whole effluent samples, and chronic toxicity testing will be conducted on the supernatant from settled whole effluent. Benthic sediment toxicity testing will be conducted on the settled solids portion of the whole effluent. Results from the initial toxicity testing will be shared with U.S. EPA so that any modifications in test design/methodology can be implemented early in the process.

2.2 Whole Effluent Acute Toxicity Testing

The acute toxicity testing will consist of four separate events during 1 year, using dilutions of whole effluent samples. Recognizing that discharges only occur on an Aas needed@ basis during high receiving water flows, an attempt will be made, (to the extent possible) to incorporate seasonal variability into the sampling and testing schedule. Additionally, when the whole effluent samples are collected, the sample will include representative Aworst case@ solids discharge conditions in the composite sample (e.g., second day hosing down operations). The acute toxicity testing will be conducted in accordance with EA=s Standard Operating Procedures (EA 1996) which are consistent with U.S. EPA=s (EPA 1993) *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms,* Fourth Edition. Whole effluent toxicity (WET) testing will be conducted using two standard freshwater test species (a fish and an invertebrate)

> Fathead minnows, *Pimephales promelas* (96 hr static acute tests)
>
> Water flea, *Daphnia magna* (48 hr static acute tests)

This results in eight WET acute tests (4 discharge events X 2 species).

For each testing event, static acute toxicity tests will be performed with *D. magna* (48 hour) and *P. promelas* (96 hour). The use of *Daphnia magna* for acute WET testing in the NPDES program is common, and the neonates are *somewhat* larger than the alternate invertebrate test species. A sample of upstream Potomac River water will serve as the dilution water for the acute toxicity tests. We propose that the tests will consist of five whole effluent concentrations: for example 100, 50, 25, 12.5, 6.25 percent effluent, an upstream Potomac River control, and a laboratory water control (moderately hard synthetic water). This dilution series could be modified based on the results of the dilution modeling discussed above. At test initiation, the *D. magna* will be # 24-hour old neonates, while the *P.*

promelas test organisms will be 1-14 days in age. The test organisms will not be fed during the exposure period. The test chambers (effluent treatments and control) will be gently aerated at a rate of approximately 100 bubbles per minute during the tests to achieve some mixing of the effluent.

In addition to the *D. magna* and *P. promelas* testing, striped bass (*Morone saxatilis*) will be evaluated during the whole effluent acute toxicity testing portion of this study. Testing will be initiated with *M. saxatilis* prolarvae (2-9 days posthatch). Because *M. saxatilis* embryos and larvae are only available during a very limited portion of the year, the *M. saxatilis* testing may not be possible during all four sampling events. As ASTM Standard Guide E 1241-92 observes, Astriped bass embryos and larvae are difficult to work with@ the proposed aeration/mixing of the test solutions may not be an acceptable practice for the proposed striped bass prolarvae testing, and the results will need to be interpreted with caution.

2.3 Particulate Phase (Supernatant) Chronic Testing

Chronic toxicity of the discharge will be evaluated four separate times during a 1 year period using dilutions of a supernatant prepared from settled effluent samples. Testing methodologies will be in accordance with U.S. EPA=s (1994a) *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms* (EPA/600/4-91/002). The chronic toxicity testing will be performed using three species (fish, invertebrate, and plant)

Fathead minnow, *P. promelas* 7-day larval survival and growth test

(EPA Method 1000.0)

Water flea, *Ceriodaphnia dubia* survival and reproduction test
(EPA Method 1002.0)

Green algae, *Selenastrum capricornutum* 96-hour growth test
(EPA Method 1003.0)

This results in 12 chronic tests (4 discharge samples X 3 species).

The suspended particulate phase preparation procedure will be a modification of the elutriate preparation described in EPA/COE=s (1998) Inland Testing Manual. The modification will be that the effluent sample will <u>not</u> be diluted 4:1 with upstream dilution water prior to mixing and settling. The suspended particulate phase will be prepared by stirring the effluent sample for 30 minutes, allowing the sample to settle for one hour, and then using the resulting effluent supernatant as the 100 percent suspended particulate phase sample. Particulate material will not be kept in suspension during the chronic testing. The *S. capricornutum* algal growth test requires that the sample be filtered through a 0.45 Fm filter prior to testing. Effluent dilutions for testing (e.g., 100, 50, 25, 12.5, 6.25 percent) will be prepared by diluting the 100 percent supernatant sample with upstream Potomac

River water. The control treatments will consist of an upstream Potomac River water control, and a laboratory freshwater control. The laboratory control water (per EPA (1994a) guidelines for *P. promelas* and *C. dubia)* will be moderately hard synthetic water, and algal media will be utilized for the *S. capricornutum* testing.

2.4 Benthic Testing

The benthic testing portion of the toxicity characterization study will consist of four test events during a 1 year period to address the suspended solids in the effluent samples [4 acute tests = 4 discharge events X 1 species]. Ten day acute toxicity tests (survival and growth endpoints) will be performed using the amphipod, *Hyalella azteca*. Methods will follow U.S. EPA=s (1994b) freshwater sediment toxicity testing protocol manual to the extent possible, since the sample is an effluent, not a sediment. Testing will employ two overlying water renewals per day.

Natural Potomac River surficial sediment samples will be layered in the test chambers (300 ml lipless beakers), and the effluent samples will be allowed to settle onto these sediments. To obtain dose-response data for the benthic testing, the 100 percent effluent samples will be diluted using upstream Potomac River water such that the data can be compared to controls, and interpreted relative to effluent/particulate dilutions at the edge of appropriate mixing zones (e.g., 50, 25, 12.5 percent effluent samples settled onto river sediment). These exposure concentrations may be adjusted based on the results of the modeling program discussed in Section 1 above. Control treatments

will be natural Potomac River surficial sediment, and a separate artificial laboratory sediment with similar grain size distribution layered over the base Potomac River sediment layer.

All toxicity test results will be interpreted relative to dilutions at the edge of acute and chronic mixing zones. Initially, effluent samples from Outfall 003 will be tested, assuming that this represents the Aworst case@ (more solids and less dilution). However with a goal of collecting samples representing four seasonal conditions, evaluation of samples from Outfalls 002 and 004 may be necessary.

3. Effluent Chemical Characterization

3.1 Goal

Use existing effluent data on concentrations of solids and key chemical constituents in the discharges to calculate preliminary projections of receiving water concentrations in comparison to ambient water quality criteria.

3.2 Approach

Existing effluent monitoring data (flow, chemical parameters) collected at the basin discharge points will be obtained and evaluated to help compare concentrations at the edge of the acute and chronic mixing zones to the ambient water quality criteria. Reasonable potential procedures (as outlined in EPA's (1991) Technical Support Document) that statistically project an effluent concentration by accounting for effluent variability and the uncertaintly associated with small data sets will not be used for this preliminary screening. Rather the existing effluent data will be adjusted using only the acute and chronic dilutions factors and the adjusted concentrations will be compared to water quality criteria. In addition, effluent samples used in the toxicity testing program will be analyzed for key parameters (e.g., total suspended solids, total and dissolved aluminum, total iron, total organic carbon, BOD, pH, alkalinity, and nitrogen and phosphorus compounds). All analytical methods used will be U.S. EPA-approved (e.g., 40 CFR 136). As additional data are collected and the variability of effluent concentrations analyzed, the Technical Support Document's reasonable potential procedures may be used to further evaluate the need for effluent controls on key parameters.

4. Fisheries Issues

4.1 Goals

U.S. EPA Region III expressed concern that key anadromous and resident fish species might potentially be affected by the Aqueduct discharges based upon general life history data. Four specific goals have been identified for study: (1) identify the critical life stages and habitat requirements of the fish *species of concern* in the vicinity of the Aqueduct outfalls, (2) assess the amount of potential fish habitat that may be influenced by the discharge plumes, (3) assess the overall potential for impacts to *species of concern* from the discharge, and (4) identify Aqueduct discharge management scenarios that may minimize potential impacts to fisheries resources that may be at risk.

4.2 Approach

A literature review will be conducted to identify the critical life stages and habitat requirements of fish *species of concern* in the vicinity of the Aqueduct outfalls. Fish species identified in U.S. EPA Region III=s Conceptual SOW and other Aspecies of importance@ to local resource professionals will be the potential species evaluated in this study. Resource agencies including USFWS, NMFS, DC Fish and Wildlife, MDNR and the Maryland Heritage Program will be consulted to derive the list of locally important species. This list (at a minimum) will include both anadromous and resident species of commercial and recreational importance that are known to utilize the Potomac River in the general vicinity of Washington, D.C. for at least part of their life cycle. For example:

Anadromous species	**Resident Species**
Striped bass (*Morone saxatilis*)	Yellow perch (*Perca flavescens*)
White perch (*Morone americana*)	Smallmouth bass (*Micropterus dolomieu*)
American shad (*Alosa sapidissima*)	Sunfish species (*Lepomis* spp.)
Blueback herring (*Alosa aestivalis*)	Channel catfish (*Ictalurus punctatus*)

Alewife (*Alosa pseudoharengus*)	Brown bullhead (*Ictalurus nebulosus*)

For each *species of concern*, life history, distribution, and optimal habitat requirements for the Potomac drainage populations will be gathered from contemporary and historical literature. Information will be tabulated to derive a range of optimum river temperatures at which the sensitive life stages (e.g., spawning, egg, larval development) of the species occur and the approximate duration of the spawning/rearing period. Historical Potomac River water temperature information will be retrieved from the USGS database and compared to the optimum spawning/rearing temperatures of sensitive life stages to identify the months during which Aqueduct discharges could potentially affect species of concern. In addition, the length of spawning and rearing periods for each species of concern will be compared to the typical Aqueduct discharge duration to assess the potential that a discharge event could disrupt the development of an entire cohort of a species within the Potomac River.

The habitat assessment proposed for the Washington aqueduct will examine macrohabitat features within the vicinity of the Aqueduct outfalls both inside and outside of the area of plume influence. The assessment will be focused on documenting the availability of various habitat features and not specifically on habitat quality. The macrohabitat features in the reach from 100-200 meters upstream of Outfall 002 down to Roosevelt Island will be mapped during a float trip of the area.

Once the area of potential plume influence is understood (from plume mapping), transects will be assessed within, upstream of, and downstream from the area of solids influence. A minimum of one transect will be assessed upstream of Outfall 002. Five or 6 transects will be assessed within the plume area and at least 2 others will be assessed outside of the influence of the plume (preferably downstream). The extent of various macrohabitat features present along each transect will be documented. This will include: substrate; embeddedness; extent of riffle, run, pool habitat; depth of riffles, runs, pools; and extent of instream cover features.

The preferred habitats of the species of concern will be derived for existing life history information. The extent of preferred habitat inside and outside of the area of plume influence will be evaluated based upon the habitat mapping and transect data. The potential for impacts of the plume to key habitats of the species of concern will be evaluated on this basis.

Sediment suspension and deposition modeling (Section 1) will help identify the appropriate areal extent of potential fish habitat influenced by each outfall. To assess potential disturbances to reproductive success, the available habitat affected by the discharge (based on the modeling) will be compared to optimum spawning habitats or known spawning areas for the *species of concern* in this reach of the Potomac. The proportion of spawning/rearing habitat affected by the discharge will be compared to the availability of comparable spawning/rearing habitat in the immediate vicinity outside the discharge area.

The spawning and habitat evaluations will help to define the risk that the discharge may have on *species of concern*. Based on the results of the fisheries literature search, in combination with the U.S. Fish and Wildlife Service=s (2 March 99) recommendations, Aqueduct discharge management scenarios will be suggested (if warranted) to minimize potential impacts to fisheries resources in the areas identified as potentially at risk.

5. Aluminum Criteria Modification

5.1 Goals

<u>If</u> aluminum is determined to exceed applicable ambient water quality standards (see EPA=s note in 63 Fed Reg 68361; 10 Dec 98) at the edge of mixing zones, it may be desirable to quantify the Abioavailability@ of the aluminum in the effluent so that the ambient standard can be appropriately adjusted (e.g., if the same concentration of total aluminum is half as toxic in Outfall 003 effluent than total aluminum salts are in pure lab water, EPA guidance would allow the standard to be multiplied by a factor of 2.0).

5.2 Study Approach

EPA comments suggested using the Agency=s (1994) Water Effect Ratio (WER) procedure for aluminum. However EPA=s (1994c) WER document was not written to address this type of situation, where alum is added, solids are settled, and there is a long period of time before the water is released to the river. As a result, a modification of the WER approach is more appropriate because of the nature of the effluent matrix. More specifically, the aluminum in Aqueduct effluents is expected to be less bioavailable because of its chemical form and binding to particulates which has occurred over an extended period of time (Hall and Hall 1989). U.S. EPA=s (1994c) WER procedure does not allow for long periods for binding, and the introduction of laboratory grade aluminum salts to an effluent mixture will not yield results which reflect what happens in normal Washington Aqueduct operations, or in the Potomac River after release.

Recognize that EPA=s WER procedure introduces laboratory-grade soluble metal salts to the effluent sample and lab water sample and then allows a 1-hour binding period before initiating the side-by-side toxicity tests. A slightly modified WER procedure is therefore proposed, where the toxicological responses to a given concentration series of aluminum in Aqueduct effluent samples is compared to the response from concentrations of laboratory grade aluminum salts (e.g., aluminum chloride) in lab water. Using this approach, the WER would be based on the form(s) of aluminum actually present in the effluent sample, rather than a different form of aluminum that is *added* to the sample in the laboratory. This approach more accurately reflects the chemical forms of aluminum that actually occur in the sample and are introduced into the river (and is compared to the lab water/aluminum salts mixture that serves as the basis of U.S. EPA=s aluminum criterion)-- which is the precise goal of the Agency=s WER guidance. U.S. EPA researchers noted that "the proposed modification to the WER is acceptable provided that the ratio of effluent to upstream water to simulate downstream water does not exceed the ratio that will occur in the actual downstream water under comparable flow conditions". A more detailed study plan will be developed if this study is required.

Consistent with EPA=s (1994) guidance for freshwater WERs, the primary test species will be *Daphnia magna* (or *Ceriodaphnia dubia* if possible). The proposed secondary species will be the fathead minnow (*Pimephales promelas*).

6. Macroinvertebrate Community Studies

6.1 Goals

Use U.S. EPA=s artificial substrate approach to characterize the macroinvertebrate community prior to and after a discharge event to determine if effects are observed.

6.2 Study Approach

Artificial substrate samplers (i.e., modified Hester Dendy) will be used to obtain qualitative and quantitative samples of macroinvertebrates at upstream and downstream locations in the Potomac River. As discussed in U.S. EPA=s (1990) Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters, there are several clear advantages for this type of approach: multiplate samplers are excellent for water quality monitoring; it offers a uniform substrate for colonization; it provides habitats of known area for quantification; samples can be collected for a known period of time at known depths, and a negligible amount of debris is collected making enumeration more efficient. Limitations in a waterbody such as the Potomac River are that the units may be subject to vandalism, and the colonization units can be washed away under high flows.

Macroinvertebrate studies will focus on Outfall 003, assuming it to be the area most heavily influenced by Aqueduct discharges as a result of substantially slower river velocities (versus Outfall 002). Based on a reconnaissance of the study area, and a formal habitat assessment, sampling locations will be selected near the Outfall 003 discharge and at several locations downstream to describe a possible gradient of effect. As appropriate, one (or more) reference location(s) will also be selected and sampled upstream of Outfall 003. Upstream and downstream locations will be selected to ensure comparability of key characteristics including river velocity and depth. The reference locations will be selected to match habitat characteristics as closely as possible to the stations downstream of Outfall 003 to minimize benthic community differences due to habitat.

Two sets of artificial substrates (with 3 replicates/set) will be deployed at upstream and downstream locations in the river approximately six to eight weeks before a discharge event, to allow for colonization. Substrates will be placed a few inches above the sediment interface and oriented so that the plates are horizontal. One set will be collected before a discharge event, and the second set will be retrieved approximately 2-3 days after the event. This will allow for upstream and downstream comparisons, both before and after a solids discharge event.

7. Proposed Sequence of Events

A specific schedule for this study is not possible because of the unpredictable / receiving stream-dependent nature of the Aqueduct discharges which dictate when many of the study components occur. As requested by EPA, the following table presents a *generalized* plan for the order that

the various components might be conducted. This is not a formal schedule and the markings are only intended to indicate the general period of time that a task might be worked on.

Generalized Sequence of Events for Water Quality Studies

Study Plan Tasks	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**
Modeling												
! Model set-up	XX	XX	XX									
! Bathymetry		XX										
! Field survey #1			XX									
! Field survey #2					XX							
! Model calibration				XX		XX	XX	XX				
! Model runs								XX	XX	XX	XX	X
Toxicity testing			XX		XX		XX		XX			X
Chemical evaluations	XX	XX		XX		XX		XX		XX		X
Fishery investigations		XX		XX		XX			XX			X
WER study						XX	XX	XX	XX	XX	XX	X
Benthic study						XX	XX	XX				

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